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In re Patent Application of

PLUMMER

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Filed: September 4, 2001

Examiner:

For: METHOD FOR COMMUNICATION BETWEEN A FIRST STATION AND A SECOND STATION, AND A CONTROLLER AND REMOTE STATION USING THE COMMUNICATION METHOD

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Assistant Commissioner for Patents
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SUBMISSION OF PRIORITY DOCUMENTS

Sir:

It is respectfully requested that this application be given the benefit of the foreign filing date under the provisions of 35 U.S.C. §119 of the following, a certified copy of which is submitted herewith:

Application No.	Country of Origin	Filed
PQ9881	Australia	4 September 2000
PR0158	Australia	15 September 2000

Respectfully submitted,

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AUSTRALIA

CERTIFIED COPY OF PRIORITY DOCUMENT

Patent Office
Canberra

I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PQ 9881 for a patent by SIGNAL DATA SYSTEMS PTY LTD filed on 04 September 2000.

I further certify that pursuant to the provisions of Section 38(1) of the Patents Act 1990 a complete specification was filed on 04 September 2001 and it is an associated application to Provisional Application No. PQ 9881 and has been allocated No. 65629/01.

COMMONWEALTH OF AUSTRALIA
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WITNESS my hand this
Fourteenth day of February 2002

J. Billingsley

JULIE BILLINGSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

P/00/009 28/5/91
Regulation 3.2

ORIGINAL

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: "Method And Apparatus For Controlling A Plurality Of Remote Stations"

The invention is described in the following statement:

"Method And Apparatus For Controlling A Plurality Of Remote Stations"

Field of the Invention

This invention relates to a method and apparatus for controlling a plurality of remote stations. The invention is particularly useful in the field of irrigation systems, however the invention may also be applied to other fields.

Background Art

In many areas of the world the availability of water to maintain the natural growth of plants is either insufficient or unreliable, especially if the plants are not native to the area. For centuries this problem has been overcome by the development of irrigation systems where water is transferred from a local available source such as a river, dam or bore and used to artificially irrigate the plants.

The twentieth century has seen the further development of irrigation systems to the level of total computerised automation. This has resulted in many areas of the world having large tracts of previously unusable arid land that are now capable of producing crops of all types.

A typical irrigation system comprises of a network of underground pipes along which water is pumped. Selected valves at strategic points on this network, when activated, release water to local distribution points such as sprinklers or drippers. The method of activating these valves may vary, but typically they would be triggered by electrical, mechanical, hydraulic or manual means.

The most common electrical device comprises of an electro-mechanical solenoid. An activating current causes the device to move a spring-loaded plunger, allowing the valve to open due to the water pressure in the irrigation pipes. When this current is either removed or possibly reversed, the plunger returns to its original state thus allowing the valve to close.

The solenoids are activated, either directly or remotely, by an electrical or electronic control systems such as irrigation controllers, programmable logic controllers (PLC's) or even manual switches.

The most common form of irrigation solenoid is activated on application of a voltage of 24 volts AC. Other solenoids activate on a range of different voltages from 6 to 48 volts, either being AC or DC. In order to minimise power consumption, latching solenoids are available which enable on the receipt of a voltage pulse of one polarity and disable when a voltage pulse of the reverse polarity is received.

The typical means of transferring the current required to activate these solenoids are a pair of cables running for distances of up to two kilometres from the controlling system. The limitations on this distance are dependent on the resistance of the cable such that sufficient power is available to activate the solenoid for the required time.

Commercial irrigation sites such as farms, parks or golf courses can cover large areas, consequently the length of cabling required to service all the solenoids may run to many kilometres. Currently there are two main techniques in use to distribute power to the solenoids, referred to as 'Direct Connection' and 'Two-Wire'. A brief description of these techniques follows.

Direct connection is the older or more traditional method, which is to supply power directly from an activating relay (or similar electronic device) within a control system by a directly connected pair of cables. It should be noted that the word 'pair' only refers to the connection point at the solenoid, as the typical wiring layout of such an installation is normally a matrix of single cables with the 'pairs' only occurring at the required solenoid junction locations.

Two-wire systems provide both power and activating commands along a single network. This network is generally consists of a true 'pair' of cables and each solenoid within the network is activated by a corresponding decoder connected between it and the network. A master irrigation controller powers and issues

commands to the decoders via the pairs of cables. The format of the command communications depends on the manufacturer's preference. Many existing systems utilise tone or DTMF (Telephone-type tones) signals superimposed on the powering voltage. Normally (and preferably) the network is wired in a 'point to point' configuration between the master irrigation controller and the decoders.

Most control systems activate solenoids by applying a 24v AC 50 Hz RMS power signal to the solenoid. Although this technique appears both obvious and simple, a number of problems and limitations do occur.

A typical solenoid used requires around 3 watts at 24v to hold in, resulting in a holding current of around 300 mA. When the solenoid is activated, the inrush current can be double (or more) the holding current. Under certain site conditions, the inrush current can also increase beyond this level by quite a considerable degree.

One example of inrush current increase is where a solenoid plunger was clogged with sediment or sand. On activation, if the force of the solenoid were not sufficient to move the clogged plunger, the plunger would vibrate violently at the waveform frequency and could take a number of seconds to activate. In this case the instantaneous inrush currents could exceed four or five times the stated holding current. If this solenoid was being activated some distance from the voltage source (the irrigation controller) or if other solenoids were also being activated which used common cabling runs, the resistance of the wire could cause the following scenarios to occur:

- The solenoid would not activate.

- The voltage drop and solenoid-induced interference at the decoder could be sufficient to cause the decoder electronics to reset, fail, or run unreliably.

- If the irrigation controller is equipped with current sensing, it could shut down the section being irrigated and skip to the next section.

- The current drawn (under worst cases) could cause a fuse to blow or trip at the irrigation controller. In this case irrigation could be suspended or cancelled.

Disregarding back-EMF voltages and other considerations, it may generally be assumed that when a solenoid is activated by an AC sinusoidal voltage the maximum amount of current flow occurs at the 90 and 270 degree points of the waveform, with the zero cross (no current drawn) occurring at the 0 and 180 degree points.

As more solenoids are activated simultaneously, the current draw will consequently increase. If two solenoids are activated with similar characteristics then the current draw will almost double. The difference will depend on the resistance and length of the supplying cable. Currently most two-wire systems start to become unreliable when operating multiple solenoids over distances exceeding one or two kilometres (utilising standard irrigation cabling). Some manufactures overcome this problem by specifying thicker or custom manufactured cabling, which greatly increases the cost of the installation.

Disclosure of the Invention

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

In accordance with a first aspect of this invention, there is provided a method for controlling a plurality of remote stations, comprising the steps of:

Distributing power to the remote stations via a distribution medium;

Distributing a reference datum to said remote stations; and

Activating remote stations at a prescribed offset from the reference datum.

Preferably, the step of activating each remote station comprises activating that remote station at a unique prescribed offset from the reference datum.

Preferably, the step of distributing power comprises providing an alternating power signal over said distribution medium.

Preferably, the alternating power signal has substantially equally proportions of positive and negative components, averaged over time.

Preferably, the alternating power signal has a substantially square wave-form.

Preferably, the distribution medium comprises a pair of wires.

Preferably, the step of distributing a reference datum further comprises the step of distributing a plurality of activation marks after the reference datum.

Preferably, the reference datum comprises a predetermined sequence of positive and negative components in the alternating power signal.

Preferably, the activation marks comprise a further predetermined sequence of positive and negative components in the alternating power signal after the reference datum.

Preferably, the step of activating remote stations comprises the step of sending instructions to each remote station whether or not to activate embedded in said activation marks.

In accordance with a second aspect of this invention, there is provided an apparatus for controlling a plurality of remote stations connected to the apparatus by a distribution medium, the apparatus comprising:

Means for providing power to the remote stations via a distribution medium; and

Control means arranged to provide a reference datum to the remote stations and to instruct each remote station to activate, the remote station responsive to the instruction to activate at a prescribed offset from the reference datum.

Preferably, the remote station is arranged to activate at a unique prescribed offset from the reference datum.

Preferably, the means for providing power comprises a power switching circuit connected to and operating under control of the control means, the power switching circuit operable to provide an alternating power signal over said distribution medium.

Preferably, the alternating power signal has substantially equally proportions of positive and negative components, averaged over time.

Preferably, the alternating power signal has a substantially square wave-form.

Preferably, the distribution medium comprises a pair of wires.

Preferably, the control means is further arranged to provide a plurality of activation marks after the reference datum.

Preferably, the control means is arranged to provide the reference datum by controlling the power switching circuit to produce a predetermined sequence of positive and negative components in the alternating power signal.

Preferably, the control means is arranged to provide the activation marks by controlling the power switching circuit to produce a further predetermined sequence of positive and negative components in the alternating power signal after the reference datum.

Preferably, the control means is arranged to provide instructions to each remote station by controlling the power switching circuit to produce a prescribed sequence of alternating positive and negative components in the alternating power signal as the activation marks, each activation mark corresponding to an instruction to a remote station whether or not to activate.

Brief Description of the Drawings

One embodiment of this invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a system of a controller and remote stations in accordance with the preferred embodiment of this invention;

Figure 2 shows a block diagram of the controller shown in Figure 1;

Figure 3 is a block diagram of a remote station shown in Figure 1;

Figure 4a shows wave forms of a "synchronisation" pulse, a "zero" pulse and an "one" pulse used by the controller in Figure 1; and

Figure 4b shows an example alternating power signal from the controller.

Best Mode(s) for Carrying out the Invention

The embodiment will be described with reference to a controller and remote stations used in an irrigation system, however it should be appreciated that the invention may well have application in other areas where similar power management requirements exist.

Figure 1 shows the system 10 comprising a controller 12 and eight remote stations 14a – 14 h.

The remote stations 14a – 14h are connected to the controller 12 by a pair of wires 16. The remote stations 14a – 14h are connected in parallel across the pair of wires 16.

In the embodiment, the remote stations 14a – 14h comprise a decoder 18 and a solenoid 20 which, when activated, irrigates an area of land. Although the embodiment is described with reference to a single pair of wires 16 and eight remote stations, it should be appreciated that the number of remote stations will vary according to the area of land to be irrigated.

Figure 2 shows a block diagram of the controller 12, comprising a microprocessor and associated memory 22, a power circuit 24 connected to the microprocessor 22 and an interface 26 connected to the microprocessor 22.

The power circuit 24 comprises an H-Bridge circuit in the embodiment formed from four power MOSFETs 28a – 28d. The power MOSFETs 28a and 28b are connected in series between a power rail 30 and a ground rail 32. The power MOSFETs 28c and 28d are also connected in series between the power rail 30 and the ground rail 32, in parallel with the power MOSFETs 28a and 28b. A pair of terminals 34 are provided, one connected between the power MOSFETs 28a and 28b, and one connected between the power MOSFETs 28c and 28d, as shown in Figure 2. The terminals 34 are connected to the pair of wires 16. By activating the power MOSFETs 28a and 28d, and then alternately activating the power MOSFETs 28c and 28b, and alternating power signal is provided on the pair of wires 16. The power MOSFETs 28a – 28d are activated under control of the microprocessor 22 via appropriate bias circuitry 36. The interface 26 is an RS-232 serial interface in the embodiment to allow the microprocessor 22 to receive instructions from an external source if desired.

Figure 3 is a block diagram of one of the remote stations 14a – 14h. Each of the remote stations 14a – 14h are of the same general form as shown in figure 3.

Each remote station comprises a decoder 18 formed from a power and zero crossing circuit 38, a microprocessor and associated memory 40 and a power generation circuit 42.

The power and zero crossing circuit 38 is connected to the pair of wires 16. The power and zero crossing circuit 38 produces a local power supply from the alternating power signal on the pair of wires 16 for use by the microprocessor 40 and the power generation circuit 42. The power and zero crossing circuit 38 also produces a signal indicating when the alternating power signal changes plurality, which is input to the microprocessor 40.

The power generation circuit 42 operates under control of the microprocessor 40 to provide power to the solenoid 20 in accordance with instructions received from the controller 12 as will described below. The power generation circuit 42 is of the same form as the power circuit 24 of the controller 12.

The solenoids 20 used in the remote stations 14a – 14h typically require a 24V 50Hz AC power supply to activate. As a result, maximum current is drawn by the solenoids at the 90^0 and 270^0 points in the AC waveform, and negligible current is drawn at the 0^0 and 180^0 points in the AC waveform. If multiple remote stations are active simultaneously and provide power to the solenoids in a single phase, the current draw of the solenoids will become cumulative with a high peak current at the 90^0 and 270^0 points in the AC waveform and a relatively low current at the zero crossings of the AC waveform.

To avoid this problem, the system of the embodiment utilises a power distribution and communication system that allows the decoders 18 to provide power to their solenoids 20 at a different relative phase to either remote stations.

Figure 4a shows examples of a synchronisation pulse or a synch pulse, a "zero" pulse and a "one" pulse. In this embodiment, the synchronisation pulse is twice the width of the zero and one pulses.

The microprocessor 22 of the controller 12 operates to control the power circuit 24 to produce an alternating power signal that is a command string similar to that shown in figure 4b. The commands string commences with a synchronisation pulse, following which is an instruction byte. In alternative embodiments, the instruction byte may be omitted if multiple instructions are not required.

In the embodiment, eight activation pulses are sent after the instruction byte, one for each of the remote stations 14a – 14h. Other embodiments, the number of activation pulses following the instruction byte would be varied according to the number of remote stations, or alternatively a fixed number greater than the number of remote stations may be used, such as 100. Each of the activation pulses is either a zero or one pulse. Each of the activation pulses following the instruction byte addresses a particular remote station 14a – 14h, according to an addressing technique that will be described below. A zero pulse corresponds with an instruction to the corresponding remote station to switch off its solenoid 20, and a one pulse corresponds with an instruction to the corresponding remote station to switch on its solenoid 20.

The microprocessor 40 of each decoder 18 in the remote stations is arranged to detect the presence of a synchronisation pulse. It then compares the following value of the instruction byte with a stored value, and if the two are the same, the microprocessor 40 knows that the following activation pulses are commands to switch on or off remote stations. Each remote station is then arranged to listen to all of the following pulses and to keep a count of the number of remote stations that have been activated prior to receiving its own instructions. Each decoder has an address stored in the memory associated with the microprocessor 40 corresponding with the position of the pulse following the instruction byte that the decoder will take as its instruction. For example, if the decoder has an address of 4, it will take the fourth activation pulse after the instruction byte as being its instruction. If desired, the remote stations may have their address modified by using further instruction bytes.

If a remote station receives an instruction to activate its solenoid, the microprocessor 40 assigns itself a phase allocation according to the number of remote stations that have been activated before it. In the embodiment, four separate phase allocations are used, with phase one representing 0^0 following the synch pulse, phase two representing 22.5^0 following the synch pulse, phase three representing 45^0 following the synch pulse and phase four representing 67.5^0 following the synch pulse. If more than four remote stations are activated simultaneously, the fifth station would allocate itself to phase one and so forth.

Since a 50 hertz AC power waveform is not provided along the pair of wires 16, the decoders determine their phase as follows.

Upon next receiving a synch pulse, each decoder will count a number of pulses after the synch pulse to determine its phase. In Australia, the solenoids require a 50 Hz AC waveform, and so the reference is 0, 22.5, 45 and 67.5^0 are relative to a 50 Hz AC waveform. Accordingly, the 0^0 phase is commenced immediately after the synch pulse, whereas the 22.5^0 phase is delayed by 1.25 milliseconds, the 45^0 phase is delayed by 2.5 milliseconds and the 62.5^0 phase is delayed by 3.75 milliseconds. This can be determined by each decoder in a number of ways such as an internal timer, by measuring the width of pulses after the synchronisation pulse, or by counting the number of pulses after the synchronisation pulse. For example, if a 400 hertz frequency is used for the activation pulses, a phase of 22.5 degrees corresponds with two pulses and so forth.

By all of the remote stations synchronising to the synchronisation pulse, long term drift is eliminated. Advantageously, since the remote stations are powering their solenoids at spaced apart timing internals, their maximum current draw is also spaced apart to better average the power drawn by all of the remote stations from the pair of wires 16. This allows more remote stations to be powered, or alternatively for the length of the pair of wire 16 to be extended without affecting performance.

It should be appreciated that this invention is not limited to the particular embodiment described above. For example, other phase angels can be used, e.g. O°, 45°, 90° and 135°. Also, more than four phases can be used, as desired.

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Dated this Fourth day of September 2000.

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Applicant

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Perth, Western Australia
Patent Attorneys for the Applicant(s)

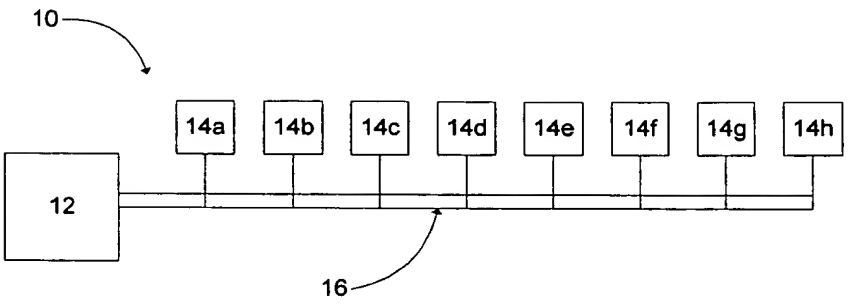

Figure 1

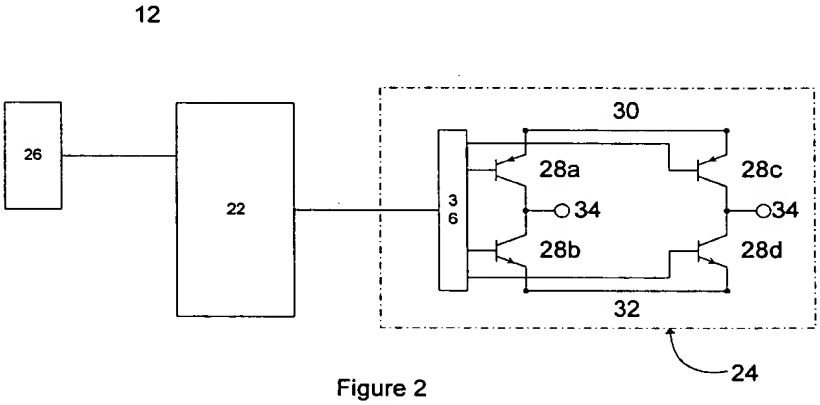

Figure 2

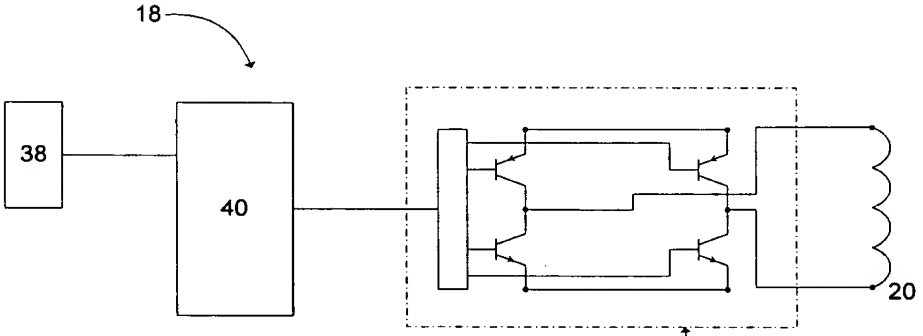

Figure 3

Figure 4A

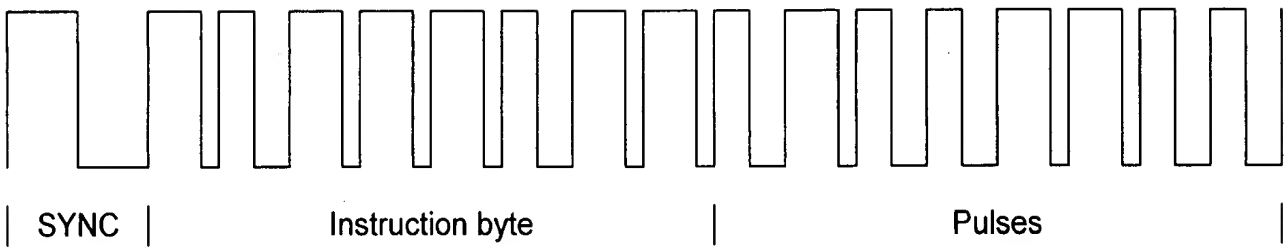

Figure 4B